

## **Geothermal Heat Pumps**

If you're planning to build a new house or replace your heating and cooling system, you may want to consider a geothermal heat pump (GHP) system. GHP systems are also known as ground-source or water-source heat pumps (as opposed to air-source heat pumps). Regardless of what you call them, energy-efficient geothermal heat pumps are available today for both residential and commercial building applications.

A GHP system can be installed in virtually any area of the country and will save energy and money. According to the Environmental Protection Agency, GHP systems are the most energy efficient, environmentally clean, and cost-effective space conditioning systems available.

While residential GHP systems are usually more expensive initially to install than other heating and cooling systems, their greater efficiency means the investment can be recouped in two to ten years. After that, energy and maintenance costs are much less than conventional heating and air-conditioning systems.

When GHP systems are installed in commercial buildings, the state-of-the-art designs are extremely competitive on up-front costs when compared with cooling towers and boilers, and they have lower energy and maintenance costs.

In addition to their cost effectiveness, GHP systems offer aesthetic advantages, quiet operation, free or reduced-cost hot water, improved comfort, and a host of other benefits.

### **What Is a Geothermal Heat Pump?**

Geothermal heat pumps are viable nationwide. They use the earth as a heat sink in the summer and a heat source in the winter, and therefore rely on the relative warmth of the earth for their heating and cooling production. Through a system of underground (or underwater) pipes, they transfer heat from the warmer earth or water source to the home in the winter, and take the heat from the home in the summer and discharge it into the cooler ground. Therefore, GHPs don't create heat; they move it from one area to another.

### **How Do They Work?**

Simply put, a GHP works much like the refrigerator in your kitchen, with the addition of a few extra valves that allow heat-exchange fluid to follow two different paths: one for heating and one for cooling. The GHP takes heat from a warm area and exchanges the heat to a cooler area, and vice versa. The beauty of such a system is that it can be used for both heating and cooling, doing away with the need for separate furnace and air-conditioning systems, and for free hot water heating during the summer months.

### **Benefits of a GHP System**

#### ***Low Energy Use***

The biggest benefit of GHPs is that they use 25-50 percent less electricity than conventional heating or cooling systems. This translates into a GHP using one unit of electricity to move three units of heat from the earth. According to a report by Oak Ridge National Laboratory, statistically valid findings show that the 4,003-unit GHP retrofit project at Fort Polk, Louisiana, will save 25.8 million kilowatt-hours (kWh)

in a typical meteorological year, or 32.5 percent of the pre-retrofit whole-community electrical consumption. This translates to an average annual savings of 6,445 kWh per housing unit. In addition, 100% of the whole-community natural gas previously used for space conditioning and water heating (260,000 therms) will be saved. In housing units that were all-electric in the pre-retrofit period, the GHPs were found to save about 42% of the pre-retrofit electrical consumption for heating, cooling, and water heating.

### ***Free or Reduced-Cost Hot Water***

Unlike any other heating and cooling system, a geothermal heat pump can provide free hot water. A device called a "desuperheater" transfers excess heat from the heat pump's compressor to the hot water tank. In the summer, hot water is provided free; in the winter, water heating costs are cut roughly in half.

### ***Year-Round Comfort***

While producing lower heating bills, geothermal heat pumps are quieter than conventional systems and improve humidity control. These features help explain why customer surveys regularly show high levels of user satisfaction, usually well over 90 percent.

### ***Design Features***

Geothermal heat pump systems allow for design flexibility and can be installed in both new and retrofit situations. Because the hardware requires less space than that needed by conventional HVAC systems, the equipment rooms can be greatly scaled down in size, freeing space for productive use.

And, geothermal heat pump systems usually use the existing ductwork in the building and provide simultaneous heating and cooling without the need for a four-pipe system.

### ***Low Environmental Impact***

Because a GHP system is so efficient, it uses a lot less energy to maintain comfortable indoor temperatures. This means that less energy - often created from burning fossil fuels - is needed to operate a GHP. According to the EPA, geothermal heat pumps can reduce energy consumption - and corresponding emissions - up to 44 percent compared to air-source heat pumps and up to 72 percent compared to electric resistance heating with standard air-conditioning equipment.

### ***Low Maintenance***

According to a study completed for the Geothermal Heat Pump Consortium (GHPC), buildings/homes with GHP systems had average total maintenance costs ranging from 6 to 11 cents per square foot, or about one-third that of conventional systems. Because the workhorse part of the system - the piping - is underground or underwater, there is little maintenance required. Occasional cleaning of the heat exchanger coils and regularly changing the air filters are about all the work necessary to keep the system in good running order.

### ***Zone Heating and Cooling for Buildings***

These systems provide excellent "zone" space conditioning. With this, different areas of the building can be heated or cooled to different temperatures simultaneously. For example, GHP systems can easily move heat from computer rooms (which need constant cooling) to the perimeter walls for winter heating in commercial buildings. School officials like the flexibility of heating or cooling just auditoriums or gymnasiums for special events - rather than the entire school.

### ***Durability***

Because GHP systems have relatively few moving parts, and because those parts are sheltered inside a building, they are durable and highly reliable. The underground piping often carries warranties of 25 to 50 years, and the GHPs often last 20 years or more.

### ***Reduced Vandalism***

GHPs usually have no outdoor compressors or cooling towers, so the potential for vandalism is eliminated.

## Installation

Because of the technical knowledge and equipment needed to properly install the piping, GHP system installations are not a do-it-yourself project.

To find a qualified installer, call the South Carolina Energy Office, your local utility company, the International Ground Source Heat Pump Association (IGSHPA - see Source List), or the Geothermal Heat Pump Consortium (GHPC - see Source List) for their listing of qualified installers in your area. Installers should be certified and experienced. Ask for references, especially from owners of systems that are several years old, and check them.

## How GHPs Are Labeled

GHP efficiency is rated in two ways. The Coefficient of Performance, or COP, and Energy Efficiency Rating, or EER, are measures of heating and cooling efficiency, respectively.

Manufacturers of high-efficiency geothermal heat pumps voluntarily use the EPA ENERGY STAR® label on qualifying equipment and related product literature. If you are purchasing a geothermal heat pump and are uncertain whether it meets ENERGY STAR® qualifications, ask for an efficiency rating of at least 2.8 COP or 13 EER.

## Financing a GHP System

Many geothermal heat pump systems carry the U.S. Department of Energy (DOE) and EPA ENERGY STAR® label. Products with the ENERGY STAR® label are better for the environment. They are highly efficient, use less energy than conventional appliances, products or systems, and help reduce pollution associated with energy use.

Homeowners should also check with their utility and ask if they offer any rebates, financing, or special electric rate programs. Another way to help finance the purchase of a GHP system is to roll the cost into an "energy-efficient mortgage" that would cover this and other energy-saving improvements to the home. Banks and mortgage companies can provide more information on these loans.

These mortgages can create positive cash flow from the start. Say that installing a geothermal heat pump system adds \$25 per month to the mortgage. However, because a GHP system is so efficient, it will save more than \$30 per month in energy costs.

## Install a GHP and Forget about High Energy Bills

With a geothermal heat pump system, you'll experience greater indoor comfort, lower energy bills, and a system that provides heating, cooling, and hot water for many trouble-free years to come.

## How Does a GHP System Work?

The ground heat exchanger in a GHP system is made up of a closed or open loop pipe system. Most common is the closed loop, in which high-density polyethylene pipe is buried horizontally at 4-6 feet deep or vertically at 100 to 400 feet deep. These pipes are filled with an environmentally-friendly antifreeze/water solution that acts as a heat exchanger. In the winter, the fluid in the pipes extracts heat from the earth and carries it into the building. In the summer, the system reverses and takes heat from the building and deposits it to the cooler ground.

The air delivery ductwork distributes the heated or cooled air through the house's ductwork, just like conventional systems. The box that contains the indoor coil and fan is sometimes called the air handler because it moves house air through the heat pump for heating or cooling. The air handler contains a large blower and a filter just like conventional air conditioners.

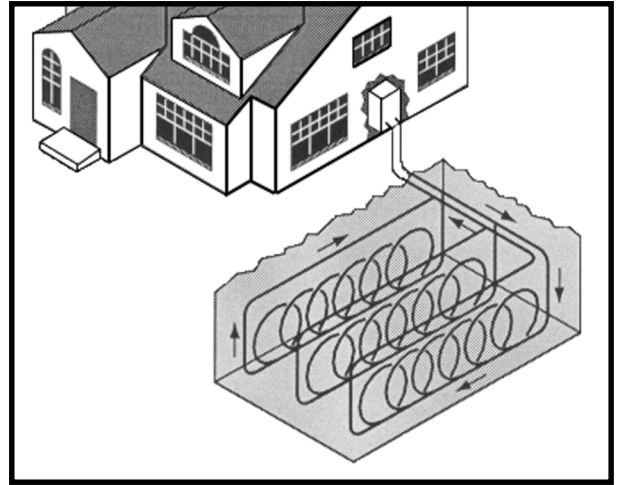
## *Types of GHP Systems*

There are four basic types of ground loop systems. Three of these - horizontal, vertical, and pond/lake - are closed-loop systems. The fourth type of system is the open-loop option. Which one of these is best depends on the climate, soil conditions, available land, and local installation costs at the site. All of these approaches can be used for residential and commercial building applications.

## Closed-Loop Systems

### *Horizontal*

This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-foot wide trench. Or, the Slinky™ method of looping pipe allows more pipe in a shorter trench, which cuts down on installation costs and makes horizontal installation possible in areas it would not be with conventional horizontal applications.

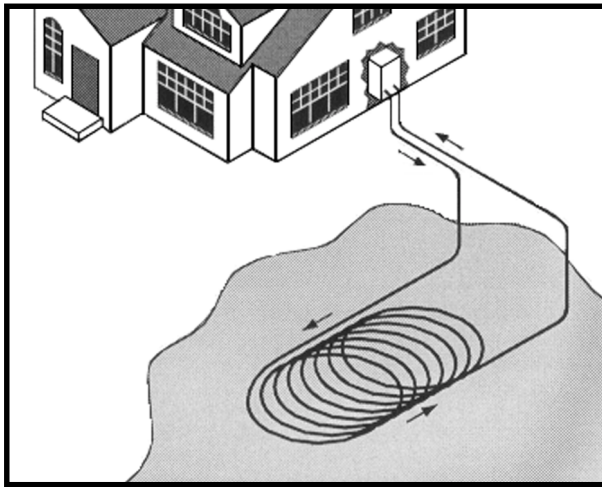
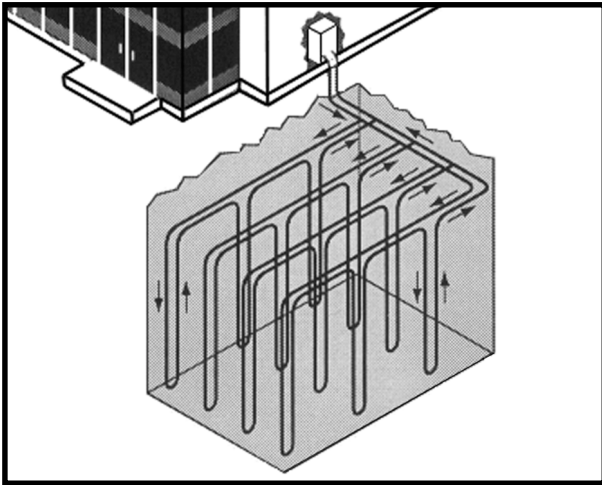


### *Vertical*

Large commercial buildings and schools often use vertical systems because the land area required for horizontal loops would be prohibitive. Vertical loops are also used where the soil is too shallow for trenching, and they minimize the disturbance to existing landscaping. For a vertical system, holes (approximately four inches in diameter) are drilled about 20 feet apart and 100 to 400 feet deep. Into these holes go two pipes that are connected at the bottom with a U-bend to form a loop. The vertical loops are connected with horizontal pipe (i.e., manifold), placed in trenches, and connected to the heat pump in the building.

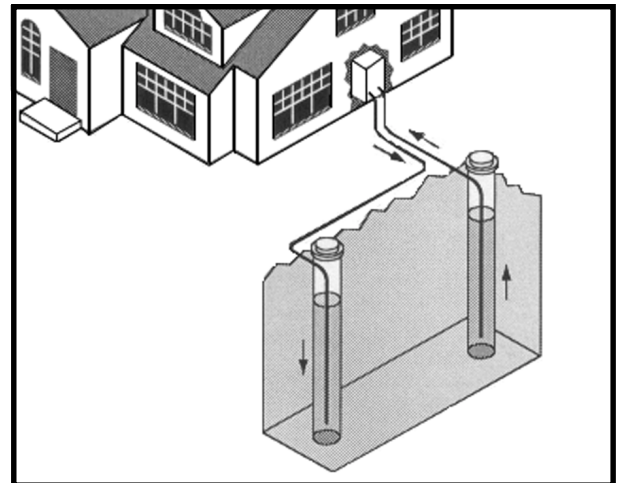
### *Pond/Lake*

If the site has an adequate water body, this may be the lowest cost option. A supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria.



## Open-Loop Systems

This type of system uses well(s) or surface body water as the heat exchange fluid that circulates directly through the GHP system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.





## Source List

### **South Carolina Energy Office**

1201 Main Street, Suite 820  
Columbia, SC 29201  
(803) 737-8030  
(800) 851-8899  
Fax (803) 737-9846  
[www.state.sc.us/energy/](http://www.state.sc.us/energy/)

### **The Energy Efficiency and Renewable Energy Clearinghouse (EREC):**

P.O. Box 3048  
Merrifield, VA 22116  
(800) 363-3732  
Fax: (703) 893-0400  
E-mail: [doe.erec@nciinc.com](mailto:doe.erec@nciinc.com)  
[www.eren.doe.gov/erec/factsheets/factsheets.html](http://www.eren.doe.gov/erec/factsheets/factsheets.html)

*EREC and the SC Energy Office provide free general and technical information to the public on the many topics and technologies pertaining to energy efficiency and renewable energy.*

### **Geothermal Heat Pump Consortium, Inc. (GHPC)**

701 Pennsylvania Avenue, NW  
Washington, DC 20004-2696  
(202) 508-5500  
Fax (202) 508-5222  
1-888-ALL-4-GEO (255-4436)  
[www.geoexchange.org/](http://www.geoexchange.org/)

*Provides extensive information regarding geothermal heat pumps, including consumer brochures, technical reports, and a database of installers. The Web page contains case studies, published articles, list of equipment suppliers, and workshop schedules and locations. The GHPC has broad-based support and participation from DOE, the utility sector, and geothermal associations and manufacturers.*

### **Geo-Heat Center**

Oregon Institute of Technology  
3201 Campus Drive  
Klamath Falls, OR 97601  
(541) 885-1750  
Fax (541) 885-1754  
[www.oit.osshe.edu/~geoheat/](http://www.oit.osshe.edu/~geoheat/)

*Provides technical information regarding GHPs to consultants, developers, potential users, and the general public; information has been developed through extensive research and firsthand experience with hundreds of projects. Publishes a quarterly bulletin. The center's resources are available to the public through the auspices of DOE.*

### **International Ground Source Heat Pump Association (IGSHPA)**

490 Cordell South  
Oklahoma State University  
Stillwater, OK 74078-8018  
1-800-626-4747  
(405) 744-5175  
Fax: (405) 744-5283  
[www.igshpa.okstate.edu/](http://www.igshpa.okstate.edu/)

*Established in 1987 to advance geothermal/ground source heat pump technology on a local, state, national, and international level. Provides a list of equipment manufacturers, a state-by-state list of installers, and numerous design manuals and brochures for contractors, homeowners, students, and the general public.*